HEAD GEAR APPARATUS

BACKGROUND OF THE INVENTION

The present invention is directed to a head gear apparatus that incorporates a face shield and apparatus that incorporates a ventilation system. The present invention has particular application for use with a garment worn by a medical caregiver during surgical procedures.

In many surgical procedures, medical personnel wear garments that are intended to maintain a barrier between the personnel and the patient. This barrier helps maintain sterile conditions in the operating room setting by completely shrouding the medical personnel and their clothing. In addition, this barrier serves to protect the caregiver from exposure to blood and body fluids. Various organizations, such as OSHA, promulgate recommendations regarding occupational exposure to fluid-borne pathogens during medical procedures. The surgical gown or shroud helps meet these recommendations.

One such surgical gown, or personal protection system, is the PROVISION™ System, marketed by DePuy Orthopaedics Co., Inc. This system includes a helmet system that integrates with a barrier hood and gown. The hood and gown are composed of a HYTREL® elastomer (provided by DuPont deNemours) that allows heat to escape while maintaining a fluid-impervious barrier protection. In addition to the gown material, a face shield or bubble is provided to allow the caregiver a protected view of the surgical arena.

The helmet system supports at least the barrier hood. Since the medical caregiver is essentially encased within the hood and gown, ventilation is of critical importance. Ventilation is necessary for air supply, CO_2 discharge, heat control and anti-fogging of the face shield. Thus, the helmet component of the PROVISION™ System includes an air moving and filtration system. The system draws ambient air through a filter assembly and directs the filtered air through vents formed in the helmet. In the PROVISION™ System, air is directed across the face of the wearer and across the face shield. The air mover is an electric

fan that connects to an external power supply and speed control worn about the waist of the caregiver.

Certain aspects of the PROVISION™ System are described in U.S. patent No. 6,393,617, assigned to the owner of the present invention. The specification and figures of this application are incorporated herein by reference. For purposes of illustration, certain features of the helmet system described in the '617 Patent are shown in **FIG. 1**. The surgical garment **10** includes a face shield **12** attached to a fabric shroud **14**. A helmet **16** includes an interior pad **17** to improve comfort. The helmet supports a fan assembly **18** that can be adjusted fore and aft along the helmet for the comfort of the wearer. The shroud **14** incorporates a filter element **20** that is situated directly above the inlet to the fan assembly **18** when the shroud is positioned over the helmet. The filter element **20** is configured to grip the perimeter of a flange **21** formed on the fan assembly so that the filter is sealed over the fan inlet.

The ventilation aspect of the surgical garment **10** is accomplished through a ventilation duct **22** formed within the helmet **16**. The duct **22** is arranged to direct air flow from the fan assembly **18** to the front of the helmet, and more particularly across the face shield **12** and the face of the wearer. An adjustable airflow deflector **23** is positioned within the duct **22** to control the direction of air flow passing across the face shield. For instance, the deflector can be extended to its position **23'** to direct most of the air flow across the face of the caregiver wearing the garment **10**. This adjustment can be readily accomplished by grasping the control knob through the shroud **14**.

The helmet **16** is stabilized by an adjustable strap assembly **24** that is pivotably attached to the helmet. The assembly includes a forehead strap portion **25** that engages the forehead of the wearer. The forehead strap portion includes a pad for the comfort of the wearer. The strap assembly **24** also includes an adjustable nape strap portion **26** that is arranged to grip the nape of the neck of the caregiver. The nape strap portion includes two straps that are coupled through an adjustment mechanism **28**. Rotating the knob on the

adjustment mechanism **28** draws the two straps of the nape strap portion **26** together to tighten the strap assembly **24** onto the head of the wearer.

The aforementioned PROVISION™ System incorporates many features of the garment system shown in **FIG. 1**. In addition, the PROVISION™ System incorporates a chin bar that extends from the forward portion of the helmet underneath the chin of the wearer. The chin bar helps support the lower edge of the face shield **12**, especially when the caregiver moves or bends over. In another feature of the PROVISION™ System, attachment strips are provided across the front of the helmet and the central portion of the chin bar. The shroud **14** is provided with mating attachment strips so that the shroud can be removably attached to the helmet assembly. This attachment helps maintain the shroud and face shield in position even when the wearer is moving. These attachment strips incorporate hook and loop type fasteners so that the shroud can be detached and reattached as necessary.

The surgical garment **10** shown in **FIG. 1** and the PROVISION™ System provide significant advantages in comfort and ease of use over prior ventilated garments. The helmet and strap arrangements solidly support the fan assembly on the head of the caregiver, and the adjustable position of the fan assembly helps achieve a well-balanced helmet arrangement. The ventilation duct **22** directs air flow at the critical path across the face shield **12** and the face of the wearer. While this system presents a significant improvement over prior systems, there is a continuing motivation to enhance the comfort, ease of use and versatility of ventilated surgical garments.

SUMMARY OF THE INVENTION

In view of this continuing motivation, the present invention contemplates improvements to a ventilated surgical garment that increase the comfort of wearing the garment, enhance the ventilation characteristics, and improve the ease of donning the garment.

In one embodiment of the invention, a head gear apparatus comprises a helmet configured to be supported on the head of a wearer, with at least two airflow passageways defined by the helmet. A first one of the passageways is arranged to direct airflow across the back of the wearer and a second one of the passageways is arranged to direct airflow across the face of the wearer when the helmet is supported on the head of the wearer. The head gear apparatus includes a fan supported by the helmet to direct airflow through the two airflow passageways.

In one feature of this embodiment, at least one of the airflow passageways includes means for adjusting the airflow through the passageway. In a preferred embodiment, both the forward and rear passageways include means for adjusting the airflow through the corresponding passageway. The second or rear airflow passageway can includes a plurality of portals defined in the helmet adjacent the fan. The portals are arranged to direct airflow across the back of the wearer. In a most preferred embodiment, each portal includes a baffle that is arranged to specifically direct the airflow to the neck of the wearer.

The means for adjusting the airflow through the rear airflow passageway can include a louver plate disposed within the helmet between the plurality of portals and the fan. The louver plate defines a plurality of louver openings corresponding to the plurality of portals, with walls between the portals. The louver plate is slidable within the helmet to adjustably overlap at least a portion of the portals. The louver plate can preferably move from a first position in which the louver openings are aligned with the portals to permit full airflow through the portals, to a second position in which the walls completely overlap the portals, thereby effectively stopping airflow through the portals across the wearer's back.

In another embodiment of the invention, a head gear apparatus comprises a helmet configured to be supported on the head of a wearer, a number of airflow passageways defined by the helmet to direct airflow across the body of the wearer and a fan supported by the helmet to direct airflow through the number of airflow passageways. In this embodiment, a strap assembly is provided for supporting the helmet without allowing the helmet to contact the head of the wearer. The strap assembly can include a head band configured to be supported on the head of the wearer and a strap arrangement connected between the head band and the helmet to support the helmet so that the helmet is not supported directly on the head of the wearer.

In certain embodiments, this strap arrangement includes a crown strap that extends along at least the side of the wearer's head, and an attachment tab extending from the crown strap. The attachment tab is connected to the helmet. In a preferred embodiment, a pair of crown straps are provided that extend along opposite sides of the wearer's head and that are sized to meet at the crown of the wearer's head. A fastener disposed between the pair of crown straps can adjustably fasten the straps together at the top of the wearer's head.

In the preferred embodiment, each crown strap defines a cut-out with a corresponding attachment tab positioned within the cut-out. Preferably, a top portion of the attachment tab is integral with the crown strap and an opposite bottom portion of the attachment tab is connected to the helmet. The attachment tab and cut-out resiliently suspends the helmet from the strap assembly so that tightening of the head band does not exert any force on the connection between the helmet and tabs.

In a further feature of the invention, the strap assembly includes an occipital support connected to the head band. The occipital support is configured to bear against the occiput of the wearer when the head band is on the head of the wearer. In a preferred embodiment, the occipital support is vertically adjustably connected to the head band to permit adjustment of the occipital support across the distance between the head band and the occiput of the

wearer. The occipital support can include a lattice configuration for the comfort of the wearer.

In another embodiment of the invention, a head gear apparatus comprises a helmet configured to be supported on the head of a wearer and a face shield mounted to the helmet, the face shield defining a substantially clear viewing area for the wearer. A plurality of substantially transparent film layers can be removably mounted on the face shield over the viewing area. Successive layers can be removed when the layer becomes soiled, such as by splattered fluids during a surgical procedure.

In yet another embodiment of the invention, a head gear apparatus comprises a helmet configured to be supported on the head of a wearer, the helmet including a chin bar extending adjacent the chin of the wearer when the helmet is supported on the head of the wearer. The helmet defines a face opening above the chin bar. A face shield is included that is configured to cover at least a portion of the face opening. A plurality of magnetic elements are disposed between the face shield and the chin bar to attach the face shield on the chin bar. Preferably, the chin bar is continuous from one side of the helmet to the other side of the helmet.

In a preferred embodiment, the plurality of magnetic elements includes at least a pair of magnetic elements supported on the chin bar, with at least one each mounted on opposite sides of the wearer's head. A corresponding number of magnetic elements can be attached to the face shield and arranged to engage the corresponding magnetic elements on the chin bar. Most preferably, the magnetic elements on the chin bar are permanent magnets, while the elements on the face shield are metal slugs.

In another embodiment of the invention, a head gear apparatus comprises a helmet configured to be supported on the head of a wearer, the helmet including a chin bar extending adjacent the chin of the wearer when the helmet is supported on the head of the wearer. The helmet defines a face opening above the chin bar. In accordance with one feature of this embodiment, the chin bar

defines a slot. A face shield is provided that is configured to cover at least a portion of the face opening. The face shield has a lower edge and a tab extending from the lower edge. The tab is configured for engagement within the slot to hold the face shield in position on the helmet.

In a preferred embodiment, the chin bar is continuous from one side of the helmet to the other side of the helmet and the slot is defined substantially at the center of the chin bar. The chin bar can define a forward-projecting lower ledge with the slot defined within the ledge. The ledge is configured to support at least a portion of the lower edge of the face shield when the tab extends through the slot.

In another aspect of the invention, the face shield includes an upper edge opposite the lower edge, and the helmet includes an upper ledge at an upper portion of the face opening. The upper ledge is configured to receive at least a portion of the upper edge when the tab extends through the slot in the chin bar.

A surgical garment system is provided that comprises a helmet and a disposable garment. The helmet is configured to be supported on the head of a wearer, with a number of airflow passageways defined by the helmet to direct airflow across the body of the wearer. A fan assembly includes an inlet opening defined by the helmet and a fan supported by the helmet within the inlet opening to direct airflow through the number of airflow passageways. A face shield is supported on the helmet and is attached to a shroud. The shroud is sized and configured to cover at least the helmet.

In one aspect of this embodiment, the shroud includes a filter element positioned on the shroud that is sized to overlay the inlet opening and a portion of the helmet surrounding the inlet opening when the shroud is covering the helmet. The filter element defines an area greater than the area of the inlet opening when the filter element overlies the inlet opening and the helmet. This relative sizing of the filter element to the inlet opening allows for greater manufacturing tolerances with respect to the position of the shroud on the helmet.

DESCRIPTION OF THE FIGURES

FIG. 1 is a side partial cross-section view of a prior art surgical garment of the type shown in U.S. Patent No. 6,393,617.

FIG. 2 is a perspective view of a helmet for use with a surgical garment according to one embodiment of the present invention.

FIG. 3 is a front view of a face shield for use with the helmet shown in **FIG. 2**.

FIG. 4 is an enlarged view of the area **4** identified on the helmet in **FIG. 2**.

FIG. 5 is an enlarged view of the area **5** identified on the helmet in **FIG. 2**.

FIG. 6 is a side view of the helmet shown in **FIG. 2** with the face shield of **FIG. 3** mounted thereon.

FIG. 7 is a perspective view of the helmet and face shield shown in **FIG. 6**.

FIG. 8 is a rear view of the helmet and face shield shown in **FIGS. 6** and **7**.

FIG. 9 is a perspective partial view of the helmet shown in **FIG. 8**, particularly showing the fan assembly with the inlet grill removed.

FIG. 10 is a side partial cross-section view of the helmet of **FIG. 2**, particularly showing the ventilation features of the helmet.

FIG. 11 is an enlarged cross-sectional view of the area **11** identified on the helmet in **FIG. 10**.

FIG. 12 is a bottom elevational view of the rear portion of the helmet shown in **FIG. 10**, particularly showing the rear ventilation feature of one embodiment of the present invention.

FIG. 13 is a perspective view of a strap assembly for use with the helmet shown in **FIG. 2** in accordance with a further embodiment of the present invention.

FIG. 14 is a side view of the strap assembly shown in **FIG. 13** with an occipital support in accordance with another feature of the present invention.

FIG. 15 is an enlarged side view of a connection between the strap assembly of **FIG. 13** and the helmet of **FIG. 2** in accordance with one aspect of the invention.

FIG. 16 is a front perspective view of the occipital support depicted in **FIG. 14**.

FIG. 17 is a side view of the helmet and face shield shown in **FIG. 6** with a fabric shroud mounted thereto.

FIG. 18 is a perspective view of a portion of a helmet showing a modified rear ventilation arrangement in accordance with an alternative embodiment of the invention.

FIG. 19 is a perspective view of a pre-curved face shield in accordance with another embodiment of the invention in which the face shield is produced from roll stock.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

While the invention has been illustrated and described in detail in the drawings and foregoing description, the same should be considered as illustrative and not restrictive in character. It is understood that only the preferred embodiments have been presented and that all changes, modifications and further applications that come within the spirit of the invention are desired to be protected.

Referring now to **FIG. 2**, a head gear apparatus is illustrated which includes a helmet **30** in accordance with a preferred embodiment of the present invention. The helmet **30** includes a rear portion **32**, a forward ventilation duct **34**, a chin bar **36** and a pair of support struts **38**. Preferably the helmet **30** is formed by an inner shell **30**a and an outer shell **30**b that are affixed together once the interior components have been installed. The shells are preferably formed of a high impact but lightweight plastic as is known in the art. The shells **30**a and **30**b can be affixed in a conventional manner, such as through sonic welding. Alternatively, the helmet can be a single molded piece, with the interior components added through openings in the molded helmet.

As can be appreciated from **FIG. 2**, the helmet **30** covers only as little of the wearer's head as necessary to support the functional components of the helmet. Thus, the rear portion **32** and support struts **38** define large side openings **42** where the wearer's head is exposed. Likewise, the support struts and chin bar **36** define a large face opening **44** through which the caregiver looks when wearing the helmet **30**. As shown in **FIG. 2**, a forward portion **34a** of the ventilation duct **34** projects across a portion of the face opening **44**. In use, this portion **34**a subtends part of the forehead of the wearer so that the free end **34b** of the duct **34** terminates above the eyes of the wearer. As will be explained herein, this front portion **34a** does not rest on the forehead but is supported away from the wearer's head. Moreover, the free end **34b** is supported substantially out of the line of vision and preferably beyond the upper peripheral vision of the wearer. The front portion **34a** is essentially cantilevered from the rear portion **32**

and support struts **38** so that the helmet does not extend around the forehead of the wearer, as in prior art head gear apparatus.

The present invention contemplates a novel face shield **50** as shown in **FIG. 3**. This face shield **50** includes an arcuate upper edge **52** and an arcuate lower edge **54**. The lower edge **54** is configured to correspond to the contour of the chin bar **36** when the face shield **50** is mounted to the helmet **30** (as shown in **FIG. 6**). The upper edge extends as far as necessary to define the uppermost viewing area for the caregiver. Thus, as shown in **FIGS. 6** and **7**, the upper edge **52** leaves a significant portion of the face opening **44** free between the face shield **50** and the support struts **38**.

The face shield **50** is formed of a lightweight clear plastic as is known in the art (although the plastic may be tinted or coated for glare reduction). The face shield material is preferably scratch resistant, but since the surgical garment is intended for disposal after a single use the material need not be extremely durable. In one aspect of the invention, a series of peel-away transparent film layers **60** can be removably carried by the face shield **50**. The peel-away film layers **60** are formed of a transparent, thin and flexible film material, such as PET-G plastic. Preferably, the layers **60** cover all or a substantial area of the face shield. Each layer **60** can be readily removed during a surgical procedure when the layer becomes scratched or splattered. With prior face shields, a scrub nurse is frequently required to try to wipe the face shield clean of splattered fluids that obstruct the surgeon's vision. With the peel-away layers **60** of the present invention, the vision obscuring material can be removed with the layer. The layers **60** can be provided with indexed tabs (not shown) that extend away from the face shield **50** to make grasping and removing a layer easier, especially when wearing surgical gloves.

In another aspect of the invention, reliable attachment of the face shield **50** to the helmet **30** is simplified. In one feature, the chin bar **36** includes a plurality of magnetic elements **40** mounted to the chin bar. As shown in **FIG. 2**, two such magnetic elements are provided on each side of the chin bar. The face

shield **50** includes comparably positioned magnetic elements **58** mounted around the perimeter of the lower edge **54**. Preferably, the elements **40** mounted in the chin bar **36** are magnets, while the elements **58** on the face shield are formed of a magnetically attracted material, such as iron or steel slugs. The elements **40** can be embedded within the chin bar so that the surface of the magnet is generally contiguous with the surface of the chin bar. The magnetic elements **58** on the face shield can be thin metal slugs.

The magnetic attraction between the elements **40** and **58** is sufficiently strong to hold the face shield **50** tightly against the chin bar. On the other hand, the magnetic attraction is sufficiently weak to allow easy removal of the face shield from the helmet. In the preferred embodiment, the face shield **50** is initially generally planar, or only slightly curved. When the face shield is engaged to the helmet, the shield is formed into a broad curve around the face opening **44** of the helmet. This broad curve adds strength to the face shield, but more importantly ensures an undistorted panoramic view from inside the helmet. The magnetic attraction between the elements **40** and **58** must be sufficiently strong to hold the face shield **50** at this curvature against the natural tendency of the shield to spring back to its generally planar configuration. Alternatively, the face shield can be formed with a pre-determined curvature, in which case a lesser degree of magnetic attraction may be sufficient to hold the face shield to the helmet.

In the preferred embodiment, the magnetic elements **40**, **58** form one part of the mechanism for supporting and retaining the face shield **50** on the helmet **30**. In another aspect of the invention, the face shield **50** is provided with a tab **62** projecting below the lower edge **54** of the shield. This tab **62** and the upper edge **52** of the shield cooperate with features on the helmet shown in **FIGS. 4** and **5**. In **FIG. 4**, a detailed view of the free end **34**b of the ventilation duct **34** shows that the duct includes a notch plate **65** mounted thereto. The notch plate 65 is curved to conform to the expected curvature of the face shield **50** when it is mounted to the helmet. The notch plate defines an upper ledge 67 as shown in **FIG. 6**. It is understood that the upper ledge **67** can be integrally formed into the free end **34**b, rather than incorporated into a separated mounted notch plate **65**.

In the preferred embodiment, the upper edge **52** of the face shield rests adjacent to the notch plate 65 while being spaced apart from the upper ledge **67** as shown in **FIG. 6**. In alternative embodiments, the notch plate **65** can be provided with features to nominally retain the upper edge. For instance, the notch plate **65** can include a dimple at the top of the upper ledge **67** that can form a friction fit with the upper edge **52** of the face shield.

Opposite the notch plate **65**, or more particularly at the middle of the chin bar **36**, is a lower ledge **69**, as shown in **FIG. 5**. This lower ledge **69** projects slightly forward from the chin bar so that the lower edge **54** of the face shield can rest on the ledge. The ledge defines a tab slot **71** through which the tab **62** on the face shield extends when the shield is mounted on the helmet.

The magnetic elements **40**, **58**, notch plate **65** and tab/slot **62**, **71** features combine to provide a solid attachment of the face shield **50** to the helmet. In addition, these components allow for easy donning of the shroud and face shield (it being understood that the face shield is fastened to a shroud as described herein). Specifically, the face shield is mounted on the helmet by first positioning the tab **62** within the slot **71**. When the tab/slot engages, the face shield can be tilted back toward the helmet until the upper edge **52** of the shield rests against the upper ledge **67**. At this point, the sides of the face shield can be pushed inward until the magnetic elements **40**, **58** engage. The face shield **50** can be removed by reversing these steps, or by simply moving the upper edge **52** of the shield away from the upper ledge **67** and tilting the face shield forward to disconnect the magnetic elements.

The magnetic engagement of the face shield to the helmet provides a secure connection. If one side of the face shield becomes dislodged from the chin bar, the magnetic elements can be quickly re-engaged by a simple turn of the wearer's head. Once the magnetic elements of the face shield move into close proximity to the magnetic elements on the chin bar, the magnetic attraction draws the elements together, thereby re-establishing the connection between the face shield and the helmet.

Optimally, the mounting on or removal of the face shield **50** relative to the helmet can be accomplished with one hand by the wearer, rather than with both hands or with outside assistance. Moreover, the magnetic elements **40**, **58** provide a self-aligning feature for the face shield **50** so that the face shield remains centered in its proper position over the face opening **44**.

Referring now to **FIGS. 8-12**, certain aspects of the air-moving system for the present invention can be discerned. The fan assembly **18** is mounted to the back of the helmet **30** at the rear portion **32**. The assembly **18** includes a fan **74** mounted within the shells of the helmet. Preferably, the fan **74** is supported on the inner shell **30**a, while a fan opening **75** is provided in the outer shell **30**b, as seen in **FIG. 9**. The fan opening serves as an air inlet. A grill **76** extends across the opening **75** to prevent the shroud material from being drawn into the fan and to protect the wearer's fingers from encroachment into the fan. As can be appreciated from the rear view of **FIG. 8**, the fan opening extends across substantially the entire rear portion **32** of the helmet **30**.

The base of the rear portion **32** includes a power jack **78** that is electrically connected to the fan **74**. The jack **78** receives a power cable that is connected to a power supply and control system (not shown). This power supply and control system can be of the type known in the art. By way of example, this system can include a battery and speed control circuitry that permits control of the speed of the fan, and therefore the airflow rate through the helmet. This power supply and control system is preferably supported around the waist of the wearer so that the weight and bulk of the system does not present a burden on the wearer. In a preferred embodiment, the battery is a lithium ion type battery. This type of battery is lighter weight, has higher energy density, and improved cycle life in comparison to other battery types traditionally used with surgical helmets.

In accordance with one feature of the present invention, the fan assembly **18** provides air flow to both the forward and rear portions of the helmet. In one embodiment of the invention, the fan **74** directs air through a forward ventilation channel **80** and through rear ventilation portals **82**. The forward channel **80** is

formed within the ventilation duct **34** that extends from the rear portion **32** over the top of the wearer's head toward the forehead, as shown in **FIG. 10**. The forward channel **80** occupies most of the interior of the duct **34**. Preferably, the duct **34**, and therefore the channel **80**, flares out adjacent the fan **74**, as represented by the dashed lines **80** shown in **FIG. 8**, to maximize the air flow into the channel **80**.

The forward air flow passes through the channel **80** in the duct **34** and exits at the forward discharge opening **85**. The direction of this discharged airflow can be modified using the mechanism depicted in the detail view of **FIG. 11**. In particular, a deflector plate **87** is slidably disposed within the channel **80** adjacent the discharge opening. The plate **87** is connected to an adjustment knob **89** which extends through an adjustment slot **91** formed in the outer shell **30**b. The knob can be loosened to allow the deflector plate **87** to be moved in and out of the discharge opening **85**, as depicted by the bi-directional arrows. The deflector plate **87** is preferably curved so that when the plate is fully extended beyond the discharge opening **85** the plate can direct the air flow toward the face of the wearer.

As indicated above, the present invention contemplates ventilation at the rear of the helmet as well. The rear ventilation portals **82** are formed in the bottom of the rear portion **32**, as best seen in **FIG. 12**. In the illustrated embodiment, a plurality of portals **82** are defined on both sides of the helmet. In one specific embodiment, the portals **82** can constitute a single portal traversing the circumferential expanse of the multiple portals shown in **FIG. 12**. The portals **82** are configured to direct air onto the back of the wearer. In a preferred embodiment, shown in **FIG. 18**, a modified rear portion **32'** defines modified portals **82'**. In particular, each portal includes a baffle **150** that is arranged to specifically direct the airflow onto the neck of the wearer. Thus, the air flow passes along the inner surface **152** and against the baffles **150** which imparts a directional vector to the airflow through the apertures **82'**. It is understood that the baffles **150** can be provided on every portal **82'** or on only some of the portals.

In one feature of the preferred embodiment, the rear ventilation portals are adjustable from a fully opened to a fully closed configuration. Returning to **FIG. 12**, in this embodiment, an arcuate louver plate **94** is mounted within the helmet **30** above the rear ventilation portals **82**. The louver plate **94** defines a plurality of louver openings **96** that correspond in size and number to the ventilation portals **82**. The louver openings **96** are separated and flanked by walls **97** that are sized to substantially completely cover, or even overlap, the corresponding portals **82**.

The louver plate **94** is slidably mounted within the helmet so that the plate can be moved from a fully open position in which the louver openings **96** are aligned with the portals **82** to fully closed position in which the walls **97** are aligned with the portals. An adjustment knob **98** (**FIG. 10**, **12**) is attached to the louver plate **94**. The knob is slidable within a slot **99** to control the side-to-side movement of the louver plate **94**. It should be understood that the louver plate **94** can be locked in any position, including a position in which the walls **97** only partially obstruct the rear ventilation portals **82**, thereby providing the wearer with a wide range of control over the airflow across the back of the wearer.

From the above discussion, it should be appreciated that the more the rear ventilation portals 82 are blocked or occluded by the walls 97 of the louver plate 94 (and thus the lower the velocity of air flow out of the portals 82), the higher the velocity of air flow out of the forward discharge opening 85. Likewise, the less the rear ventilation portals 82 are blocked or occluded by the walls 97 of the louver plate 94 (and thus the higher the velocity of air flow out of the portals 82), the lower the velocity of air flow out of the forward discharge opening 85.

As thus far described, the helmet provides a support structure for the ventilation components and for the hood and/or shroud donned over the helmet. Another feature of the invention resides in a strap assembly **100**, shown in **FIGS. 13-16**, that supports the helmet off of the head of the wearer. In some prior art systems, at least a portion of the helmet is carried directly on the head of the caregiver. When supported in this way, the helmet not only "smothers" the portion of the head, it also prevents access of ventilation air to that portion. The

strap assembly **100** of the present invention essentially elevates the helmet off the head to allow access to the cooling airflow.

In one embodiment of the invention, the strap assembly **100** includes a head band portion **102** that is sized to fit around the head of the wearer. A front portion **103** contacts the wearer's forehead. A rear portion of the head band is split into two adjustably connected straps **104** that traverse the back of the wearer's head. As shown in **FIG. 14**, these adjustable straps **104** are offset downwardly from the front portion **103**. A diameter adjustment mechanism **106** interconnects the free ends of the adjustable straps **104** in a manner known in the art. One such adjustment mechanism is shown and described in U.S. Patent No. 6,393, 617, incorporated by reference above. The mechanism includes a rotatable knob **108** that can be used to draw the straps **104** together, thereby decreasing the circumference of the head band **102** about the caregiver's head.

The strap assembly **100** includes opposite crown straps **110** that are arranged to wrap around the crown of the wearer's head. The crown straps can be provided with opposing fastener elements **112**, **113** to allow adjustable interconnection of the free ends of the straps **110**. In a preferred embodiment, these fastener elements **112**, **113** can be mating hook and loop fasteners that can be easily engaged and re-adjusted whenever necessary. The interior of the crown straps **110**, as well as the headband **102**, can include padding for the wearer's comfort.

In addition to providing an additional feature for supporting the strap assembly **100** on the wearer's head, the crown straps **110** also incorporate the mechanism for connecting the strap assembly to the helmet **30**. As shown in **FIGS. 2** and **10**, the helmet **30** includes fastener locations **121** at the junction between the support struts **38** and the chin bar **36**. The strap assembly includes attachment tabs **115** that form part of the crown straps **110**. The tabs **115** are situated within tab cut-outs **117** defined in the straps **110**, as shown in **FIG. 13**. The upper end of each tab **115** is connected to or integral with the straps **110**, while the lower end of the tab is unattached and instead free to flex within the tab

cut-outs **117**. The lower end of each tab includes a fastening location **119** that corresponds to the fastening locations **121** of the helmet. These fastening locations **119**, **121** can be joined by a mechanical fastener, such as a brad, or by spot welding at the respective locations.

It can be appreciated that the strap assembly **100** is connected to the helmet **30** at only two locations – one on each opposite side of the helmet, namely locations **121** – as shown in **FIG. 15**. This connection allows the attachment tabs **115** to operate as a resilient support as the helmet essentially hangs from the strap assembly **100** at these tabs. The circumference of the headband **102** can be freely adjusted without exerting any force upon the interface between the strap assembly and the helmet. When the strap circumference is reduced, the crown straps **110** retract inward from the tabs **115** without compromising the connection at the locations **119**, **121**. The configuration of the tabs **115** and tab cut-outs **117** also simplify the construction of the strap assembly, since these features can be easily stamped from a flat sheet of material along with the straps **102**, **104** and **110**. Preferably, the fastener locations **121** on the helmet are oriented adjacent the temples of the wearer. In this way, the helmet can be supported in a balanced position as it hangs from the strap assembly **100**.

In a further beneficial feature of the present invention, the strap assembly **100** can include an occipital support **125**. Alternatively, the occipital support 125 may be attached directly to the helmet 30. The occipital support **125** projects below from the rear of the strap assembly. In a preferred embodiment, the occipital support includes a pair of adjustment bars **127** (**FIG. 16**) that project upward into mounting brackets **129** formed on the adjustment mechanism **106**, as shown in **FIG. 14**. The bars **127** and brackets **129** can be configured to form an adjustable fit, such as by an adjustable press-fit or an interlocking component arrangement. In this way, the vertical position of the occipital support **125** relative to the strap assembly **100** can be adjusted for the comfort of the wearer.

The occipital support **125** includes opposite support edges **131** that are arranged and configured to contact the occipital ridge at the base of the wearer's skull. The occipital support **125** employs an open lattice so that the support can flex during use. The open lattice also allows airflow through the support **125**. A hinge portion **133** can be defined between the support edges **131** to accommodate the occipital notch in the skull and to allow another degree of flex for the occipital support. The occipital support **125** thus operates as an anchor of sorts against the base of the wearer's skull that cooperates with the head band **102** to provide stable support for the helmet. This anchor effect is particularly beneficial in connection with the attachment tabs from which the forward portion of the helmet hangs. The occipital support shares the load of supporting the helmet with the head band and helps distribute that load in a more balanced manner than with prior helmet systems.

The face shield **50** is affixed to a fabric shroud, such as the shroud **140** shown in **FIG. 17**. Preferably, the shield **50** is affixed to the shroud at a sealing perimeter **56** (**FIG. 3**) adjacent the upper and lower edges **52**, **54** of the shield. The sealing engagement **142** can be accomplished in a manner conventional in the art; however, it is understood that a substantially air-tight seal of the face shield to the shroud is important. First, the air-tight seal prevents the incursion or expulsion of airborne contaminants to and from the surgical garment. Second, the air-tight seal maintains the airflow through the forward ventilation duct **34** without leakage through the face shield.

The shroud **140** includes a filter element **144** sealed or sewn to the shroud in a known manner. The filter element can be conventional in material and properties. In a preferred embodiment, the filter element includes an electrostatic media capable of removing at least 91% of aerosolized particulates down to 0.1 microns. In one embodiment of the invention, the filter element **144** is larger in area than the fan opening **75**. This larger area requires less tolerance in the position of the filter element relative to the fan assembly **18**. When the shroud **140** is mounted over the helmet **30** and the fan **74** is operating, the suction generated by the fan will be sufficient to hold the filter element **144** in position

over the fan opening **75**. The over-sized nature of the filter element relative to the fan opening ensures that only the filter element is positioned over the fan, and not the shroud material itself.

As explained above, the face shield is curved when mounted on the helmet to ensure an unobstructed, undistorted view through the face shield. In an alternative embodiment of the invention, a face shield **160** shown in **FIG. 19** can be pre-curved – i.e., it is formed with a curvature **R**. In accordance with this embodiment, this pre-curvature is created by stamping the face shield from a sheet of roll stock. In other words, the plastic sheet material for the face shield **160** can be provided wound on a roll as roll stock. The sheet is unwound from the roll stock for stamping into the shape shown in **FIG. 19**. However, since the sheet material is rolled, it develops a shape memory curvature. This curvature **R** gives the face shield **160** its pre-curved configuration that facilitates mounting on the helmet **30**. As explained above, the face shield **160** is mounted on the helmet by extending the tab **161** through the slot **71** in the chin bar (see **FIG. 8**). The pre-curvature of the face shield automatically places the magnetic elements (not shown), such as the elements **58** (see **FIG. 3**) in close proximity to the magnetic elements **40** on the chin bar (see **FIG. 2**). In some cases, once the face shield tab is properly positioned, the magnetic elements **40, 58** will automatically engage so that the face shield is quickly and easily mounted on the helmet.

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiments illustrated in the drawings and described in the following written specification. It is understood that no limitation to the scope of the invention is thereby intended. It is further understood that the present invention includes any alterations and modifications to the illustrated embodiments and includes further applications of the principles of the invention as would normally occur to one skilled in the art to which this invention pertains.